Uncertainty for the AERONET data (nLw) at Venice and MOBY data matchup.

## Ocean EDR Rehearsal Plans Phase II
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Introduction to Uncertainty Analysis (first approach)

Our first approach to Uncertainty Analysis was the definition of an uncertainty Map retrieved considering covariance-pixels <= max covariance value. This Map represents the satellite uncertainty reduction (error) in the selected area and was used to assign the best in situ position (as the result of the merging). Impact Index that represents the effective error reduction (due to the in situ) in a fixed area.
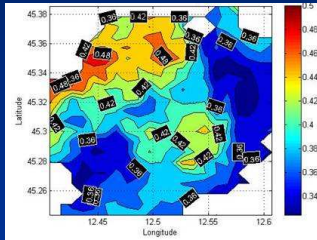
Uncertainly Map
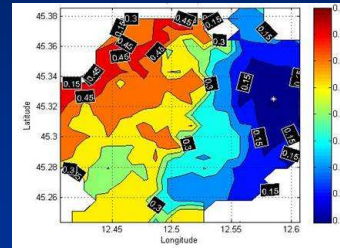
Impact Map
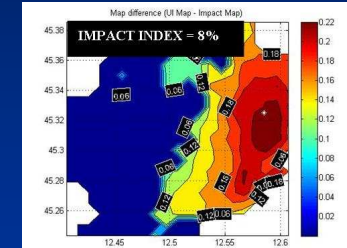
Impact Index

This approach can be used to identify the best locations of in situ sampling and to define where the in situ data should be collected in order to have the best results for calibration and validation of satellite products (for example to plan cruises or autonomous vehicles – gliders missions).

Consideration

This approach is adequate when there is the possibility to plan the in situ sampling, however we also need to determine if the present in situ sites are adequate for assessing the uncertainty (such as MOBY, AERONET). For this purpose we have defined a new UI index that can be used to have an absolute values that is independent on the geographic position and on the size of the considered area.

Goal of Phase II:

Waiting the VIIRS launch we are continuing our study on UI indices. Our main goal is to provide uncertainty for the AERONET data (Normalize Water Leaving Radiance - nLw) at the Venice Aqua Alta station to be used for Vicarious Calibration.

NURC

We have define an index that relates the goodness of the measurement in an user defined location *to respect* (normalized) the Moby (or Aeronet, or Boussole or Gyre) official sites. The idea is to define a parameter that is independent on the size of the study area in order to provide an absolute value that can be used for several areas.

The new UI is represented with a complex number that I take into account of two important parameters: the goodness of the measurement to respect the reference site and the area of influence of the retrieved result.

$$UI = A + j\ B$$

A takes into account of the "goodness" to respect the reference site. For example if A=2 performance of the new position is lower of a factor 2.

B takes into account of "area of influence" of the selected site.

In order to have an absolute reference to relate the goodness of the study measurement, a *reference in situ* have to be defined.
On the basis of our covariance-performance analysis we have decided to use MOBY as reference (that is the more used and tested station).
The idea is to use MOBY to normalize the UI index as follow:

$$UI = \frac{Cov_{INSITU}}{Cov_{MOBY}} + j \frac{Area_{INSITU}}{Area_{MOBY}}$$

This ratio is retrieved from the evaluation of the area [km] (number of pixel x size of one pixel) with a bigger correlation. This area is identified using a threshold that depends on the correlation of the pixel of interest: $threshold = \frac{C(i,i)}{2}$

This ratio is retrieved using the covariance matrix of the *in situ* of interest (for example AERONET) and the covariance matrix of the reference *in situ* (MOBY). The value of the matrix is an index that represents the correlation of the i-pixels with the other pixels in the area. The ratio provide a value that takes into account of the "goodness" to respect the reference site.

If $\frac{Cov(i,i)}{Cov_{MOBY}} = 2$, the performance of the considered *in situ* two times lower to the MOBY performance.

MOBY reference table

| MOBY	Cov	Area [km]
Jan	0.9532	1321
Feb	0.9668	1040
Mar	0.9771	914
Apr	0.9144	1426
May	0.9787	480
Jun	0.7215	782
Jul	0.7862	701
Aug	0.9450	1180
Sep	0.9951	1222
Oct	0.988	631
Nov	0.9270	751
Dec	0.9453	382

UI index, an example of implementation

Historical Water Leaving radiance (547 nm) analysis in the month of February

STATISTICAL RESULTS:

Historical Covariance (around AERONET)

diag(C)

Time-series mean

MODIS time-series (Feb 2008-2009)
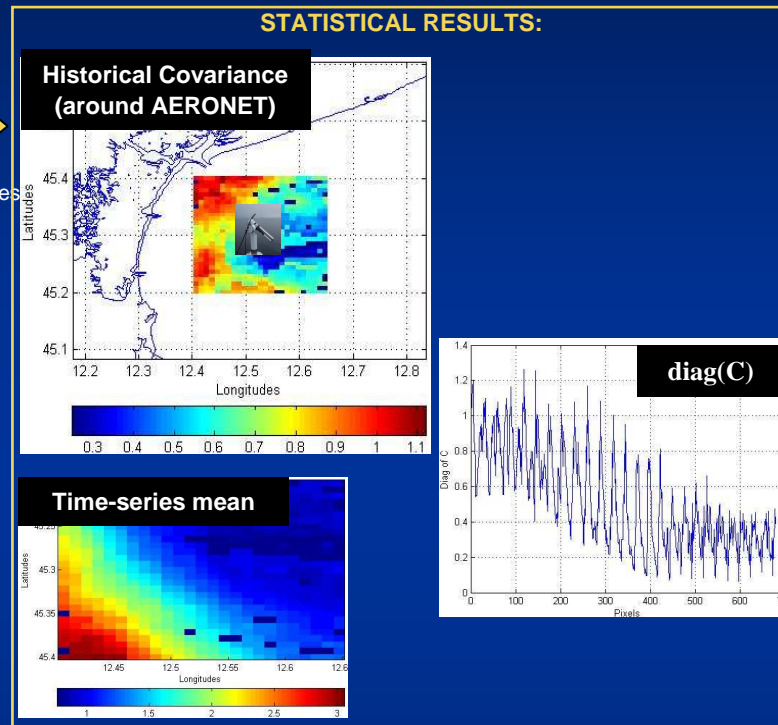
UI AERONET ANALYSIS:

$$Cov_{AERONET} = 0.9418$$

$$Area_{AERONET} = 451[\text{km}^2]$$

$$UI = \frac{0.9418}{Cov_{MOBY}} + j\frac{451}{Area_{MOBY}}$$

$$UI = \frac{0.9418}{0.9668} + j\frac{451}{1040}$$

$$UI_{February} = 0.9742 + j0.4338$$

Historical Variability (Uncertainty) to respect MOBY Performance.

Area of influence: ~0.5 means that The area is halved (to respect MOBY)

MOBY

MOBY	Cov	Area [km]
Jan	0.9532	1321
Feb	**0.9668**	**1040**
Mar	0.9771	914
Apr	0.9144	1426
May	0.9787	480
Jun	0.7215	782
Jul	0.7862	701
Aug	0.9450	1180
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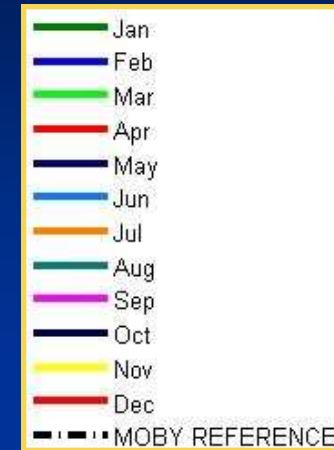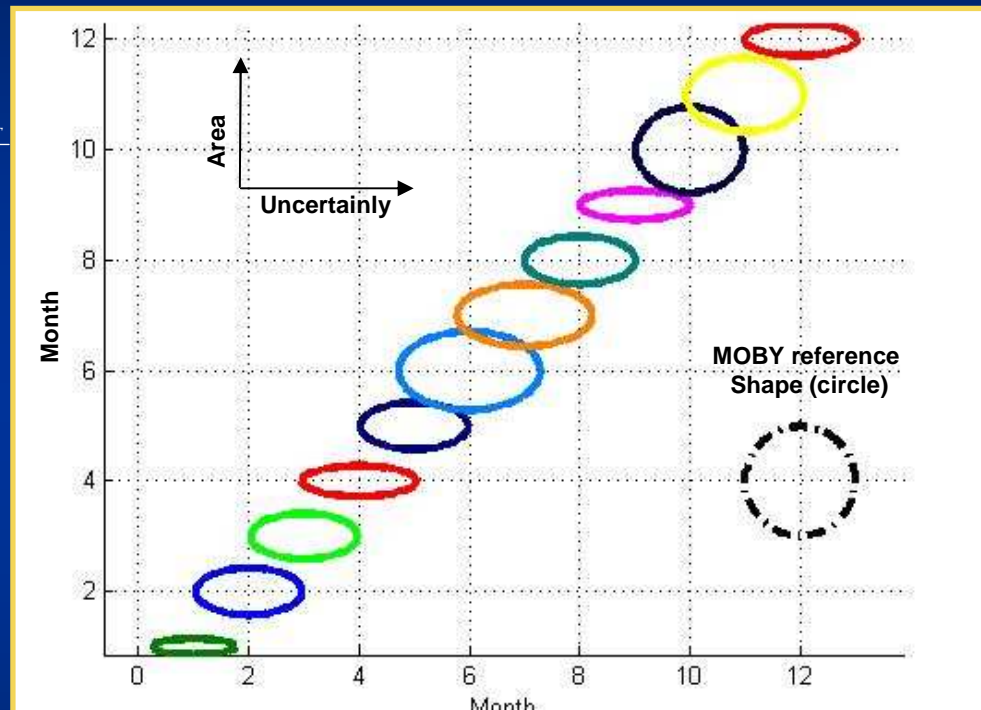$$UI = \frac{Cov_{INSITU}}{0.9668} + j\frac{Area_{INSITU}}{1040}$$

NURC

Ellipse definition:

$$\text{semimajor axis}_a = \frac{C_{AERONET}}{C_{MOBY}}$$

$$\text{semimajor axis}_b = \frac{Area_{AERONET}}{Area_{MOBY}}$$

$$\text{inclination} = 0°$$

$$\text{center} = (Month_x, Month_y)$$

MOBY reference
Shape (circle)

Jan	
Feb	
Mar	
Apr	
May	
Jun	
Jul	
Aug	
Sep	
Oct	
Nov	
Dec	
— · — · MOBY REFERENCE	

AERONET	UI index
Jan	0.7576 + j0.1528
Feb	0.9742 + j0.4338
Mar	0.98 + j0.42
Apr	1.0539 + j0.2824
May	0.9877 + j0.4333
Jun	1.2895 + j0.72
Jul	1.2388 + j0.5669
Aug	1.0172 + j0.4414
Sep	1.01 + j0.27
Oct	0.9786 + j0.7862
Nov	1.0673 + j0.6794
Dec	1.0247 + j0.2907

On the basis of the above results, it's possible to classify the performance of each month and
To build a "top-list":

1. October
2. November
3. May
4. February
5. June
6. March
7. July
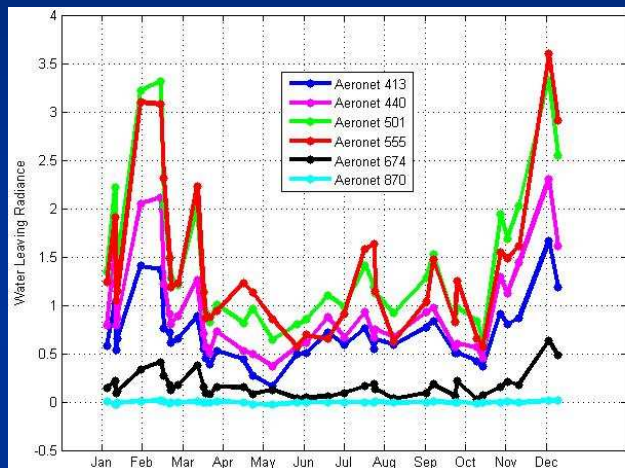8. August
9. December
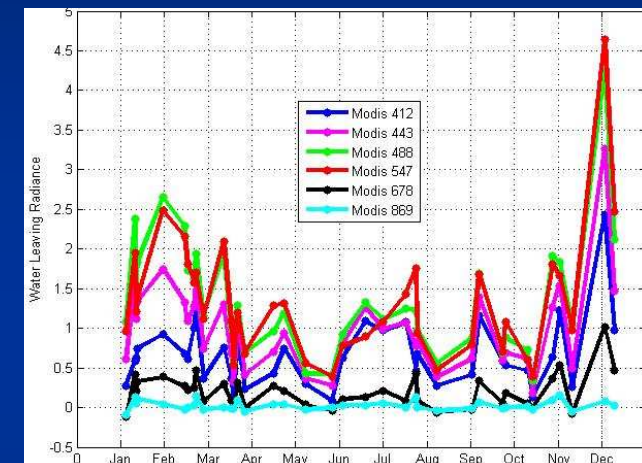10. April
11. September
12. January

We present the match-up performance between AERONET data and the clear MODIS images for the 2009 year, resulting in a dataset of 37 samples. AERONET samples have are applied to validate MODIS nLw products. Figures below summarized the results (without band shift correction).
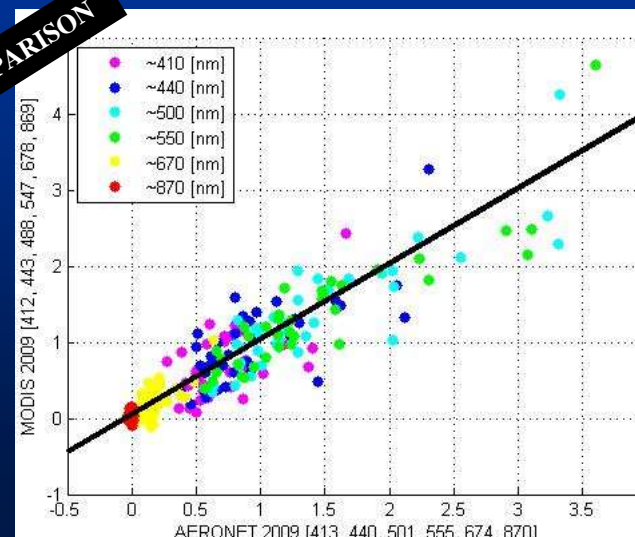
AERONET 2009 data

Jan '09

Feb '09

[…]
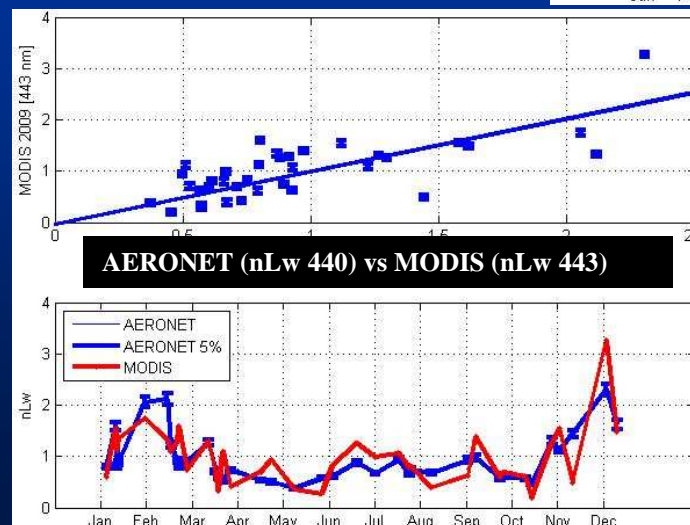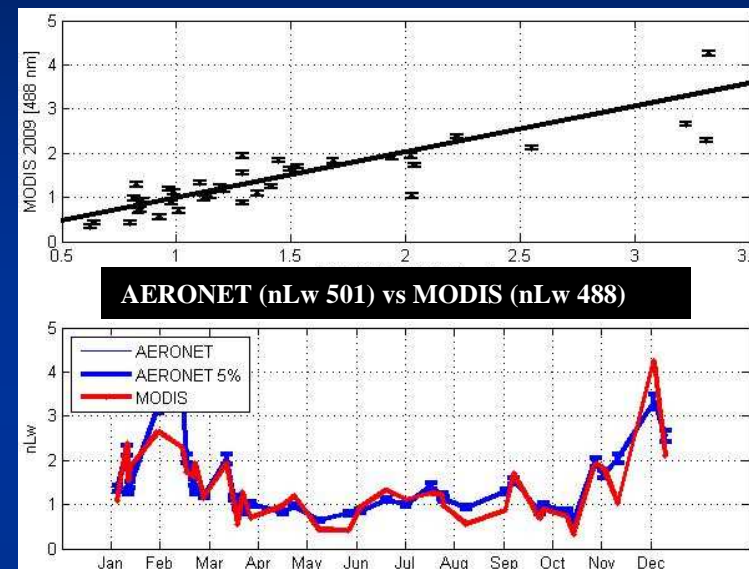
Dec '09

MODIS 2009 data

COMPARISON

These figures represent the match-up performance between AERONET data and the clear MODIS images for the 2009 year in a fixed wavelength. On the basis of the results retrieved from Zibordi *et al.* [1] we have include the SeaPRISM radiometric stability and error-bar of 5% in the 412-551 [nm] spectral range and of 8% for lambda > 551 [nm].

AERONET (nLw 555) vs MODIS (nLw 547)

AERONET (nLw 501) vs MODIS (nLw 488)

AERONET (nLw 440) vs MODIS (nLw 443)
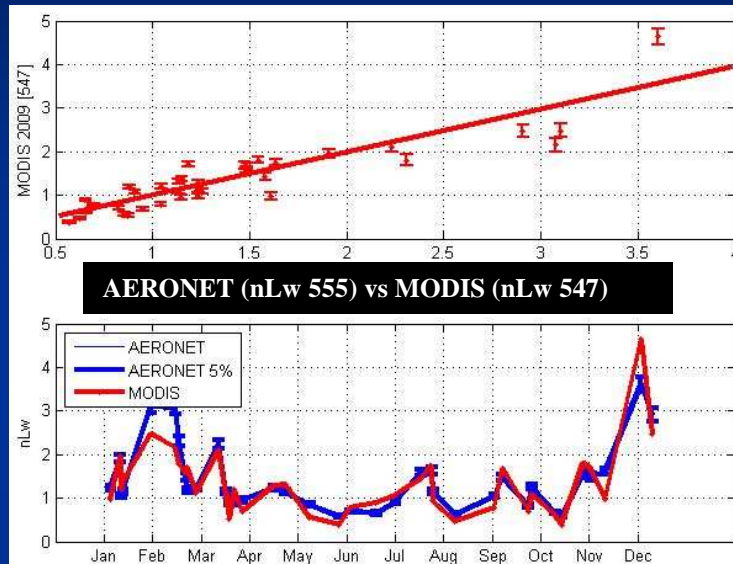
[1] G. Zibordi *et al*, AERONET-OC: A Network for the validation of Ocean Color Primary Products, Journal of atmospheric and ocean technology, 2009.
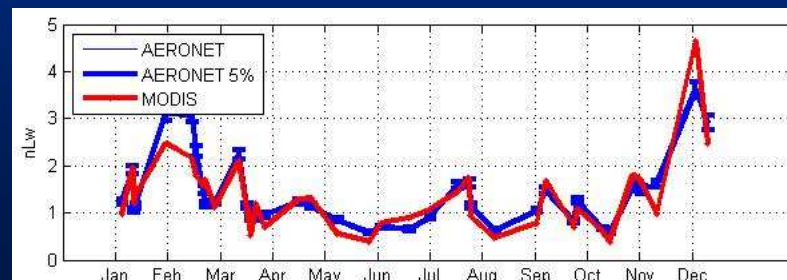
✓ We have present a new methodology to retrieve Uncertainty Index (UI) that is independent on the size of the study area. This index was using a reference *in situ* (MOBY) in order to provide an absolute value that can be used for several areas. This type of index can be used to evaluate the performance of the platform of interest (such as AERONET, Gyre or Boussole) to respect the month of interest.

$$UI = \frac{Cov_{INSITU}}{Cov_{MOBY}} + j\frac{Area_{INSITU}}{Area_{MOBY}}$$

✓ We have applied the new UI on the available historical covariance data set that have been retrieved using MODIS time-series on the Venice Aqua Alta site. This analysis allow to choice the best months in terms of *in situ* performance. These months can be used to support Calibration/Validation (Cal/Val) procedures for the Visible Infrared Imager Radiometer System (VIIRS) sensor.
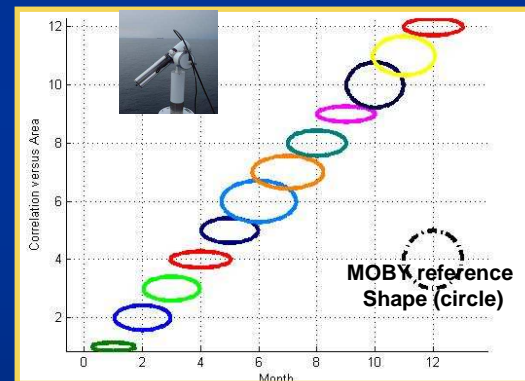
✓ We have present the match-up performance between AERONET data and the clear MODIS images for the 2009 year for normalized water leaving products.

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